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Glidewell Laboratories
4141 MacArthur Blvd.
Newport Beach, CA 92660
USA

Expertise

Wear behavior of BruxZir®

General Specifics

Designation:	Wear Test (Chewing Simulator)
Test Specimen:	Ÿ BruxZir Ÿ Ceramco®3
Sponsor:	Glidewell Laboratories 4141 MacArthur Blvd. Newport Beach, CA 92660 USA
Contact Person:	Wolfgang Friebauer, MDT, CDT
Date of Order:	Proposal 03/22/2010
Contractor/Investigator:	Prof. Dr.rer.nat Dipl.-Ing. Jürgen Geis-Gerstorfer
Realization:	Ch. Schille (PhyTA)
Date of Report:	9/15/2010

Material / Product

The following materials were investigated:

1.) BruxZir
ZrO_2 (Tosoh Material)
Lot # S 309853 P

2.) Ceramco® 3
Feldspatic Ceramic, A3 (Dentsply Material)
Lot # 09 001 402

Sample Preparation

The samples were delivered by the sponsor in a test-ready condition. Ten specimens of each material and each surface condition respectively were tested. The specimen size was ca. 10x10x2 mm.

Both groups of materials were hand prepared by the sponsor as follows:

1. Course: Diamond disk 9 µm w/300 rpm
2. Medium: Diamond disk 3 µm w/150 rpm
3. Fine: Diamond disk 1 µm w/150 rpm + Diamond polish

All samples were tested in the as delivered state.

Test Procedure

The wear tests were performed using a pin-on-disk apparatus (chewing simulator, Version 3.1.29, Willytech; Munich, Germany). The chewing procedure (simulation of bruxism) consisted of 1.2 x 10^6 cycles under a load of 50 N and a horizontal movement of 0.2 mm (in water). As antagonists, 6 mm Steatite balls were used. This protocol simulates the clinical performance of the materials over period of approx. five years.
The amount of wear was determined topographically with the use of a 3-D profilometer (Concept 3D; Mahr, Germany) by measuring the depth of wear track of the restorative material and the height loss of the antagonist.

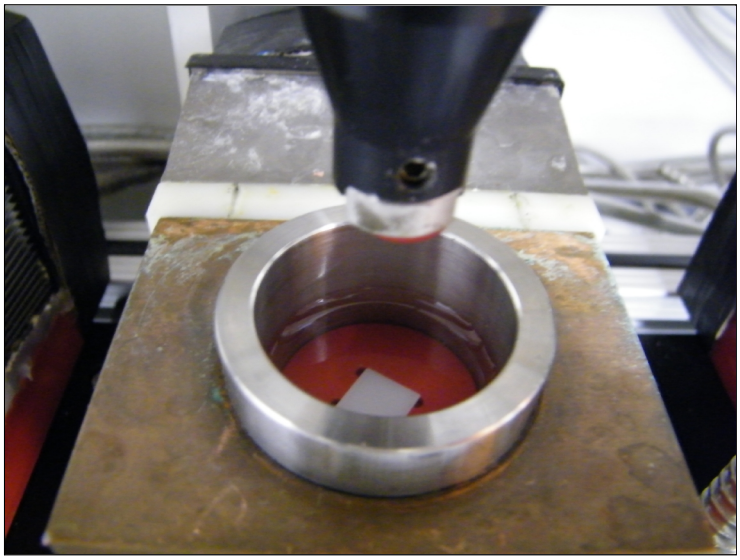

Fig. 1: Sample in test cell with antagonist/Steatite ball holder (top).

Fig. 2: Assembled test devices in the chewing simulator.

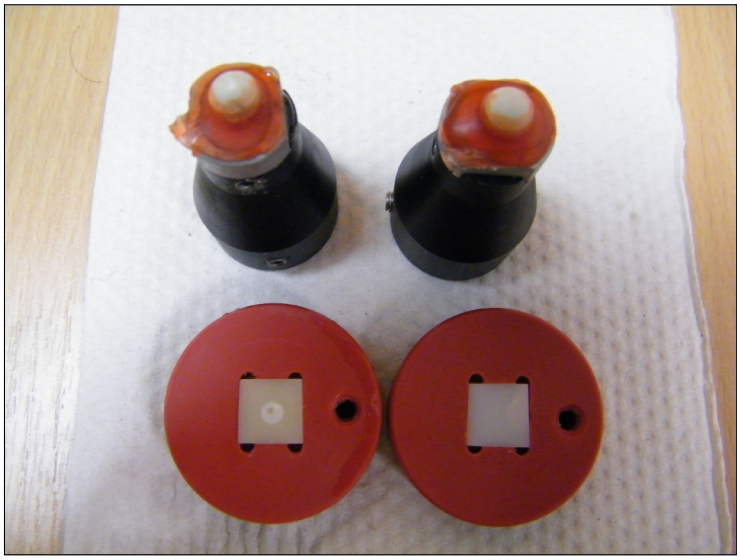

Fig. 3: Embedded Steatite balls in the antagonist holder (top), and samples after finishing the wear test (left: Ceramco®3, right: BruxZir; sample No. 10 each).

Overall three test series were performed with the chewing simulator using half of the materials at any one time (first and second run: 2x3 specimens of each material; third run: 2x4 specimens) in order to eliminate potential systematic errors during the wear tests.

To simulate moist conditions of the oral cavity, the test chambers were filled with distilled water.

As antagonists, 6 mm Steatite balls were used. The Steatite balls were polymerized in the aluminum-antagonist holders using Palavit G. A new steatite ball was applied for each test. The contact point of the antagonists was adjusted at the middle of the samples.

The cyclic two body wear tests were carried out in such a way that the antagonist hit the sample vertically with a load of 5 kg followed by a horizontal movement under a load of 0.2 mm. At the end of this track, the antagonist was lifted 5 mm and then the wear cycle was repeated at its original position 1,200,000 times. The feed-motion speed was 40 mm/min.

Determination of wear

From each sample the 3-D Topography was measured before and after the wear test with 121 measuring profiles within an area of 3x3 mm using a 3-D measuring device with a 2 µm tactile probe (Apparatus: Perthometer S6P, Mahr; Goettingen, Germany; tactile probe: MFW-250; software: Perthometer Concept 3D, Vers. 7.1). This procedure was used to calculate the maximum depth of wear Pt quantitatively.

The substance loss of the antagonist situation (Steatite balls) was determined with a calibrated stereo microscope (Wild) measuring the diameter of the flattended balls and calculating the height of wear.

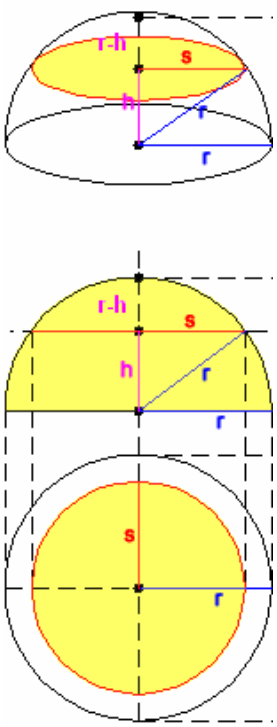

Fig. 4: Principle of the determination of wear r-h of the balls based on the abrasion radius s measured.

Results

The following tables represent the wear data of the materials investigated.

BruxZir		
Sample No.	Wear of Antagonist [µm]	Wear of Material [µm]
1	82.7	2.6
2	48.9	0.4
3	113.7	2.5
4	52.9	1.9
5	45.1	0.4
6	64.2	0.7
7	63.2	0.7
8	79.1	0.6
9	92.4	1.4
10	73.0	0.9
Mean	72	1
S.D.	21	1

Table 1: Single values of BruxZir.

Ceramco®3		
Sample No.	Wear of Antagonist [µm]	Wear of Material [µm]
1	77.5	46.9
2	81.5	91.6
3	146.2	35.0
4	110.2	50.5
5	44.1	31.7
6	194.0	82.3
7	111.2	64.1
8	158.4	Sample broken
9	122.5	31.2
10	50.6	49.2
Mittelwert	110	54
S.D.	48	22

Table 2: Single values of Ceramco®3.

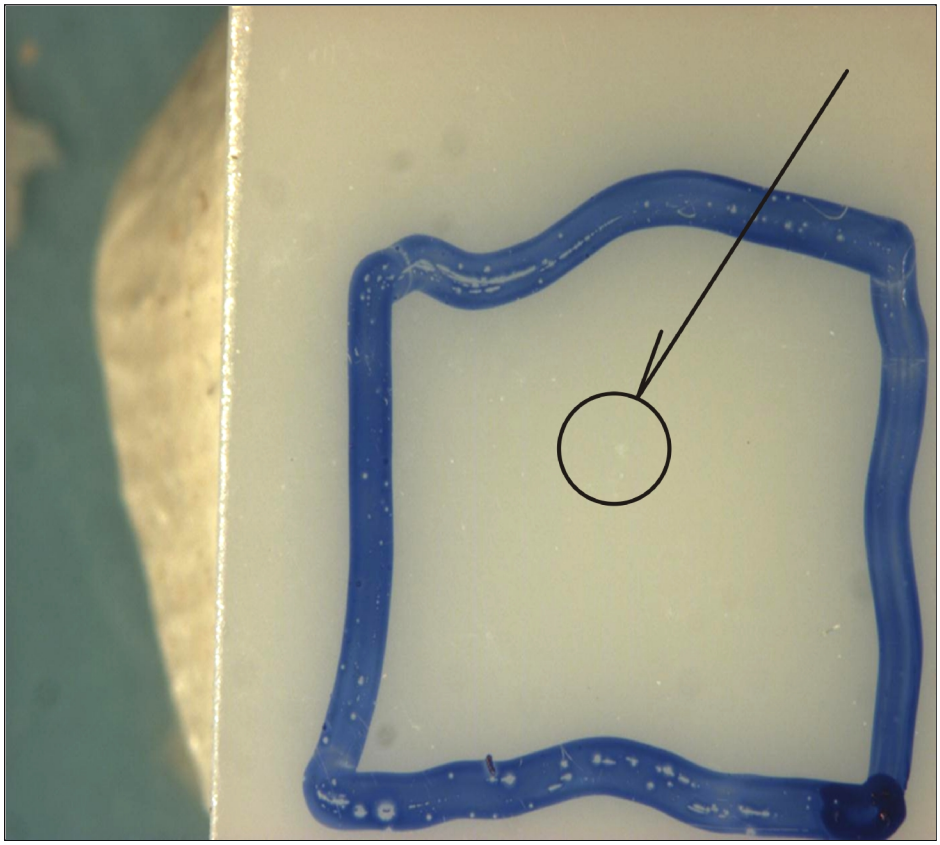

Fig. 5: **BruxZir** after wear test (sample No. 4). The contact area is indicated by the circle.

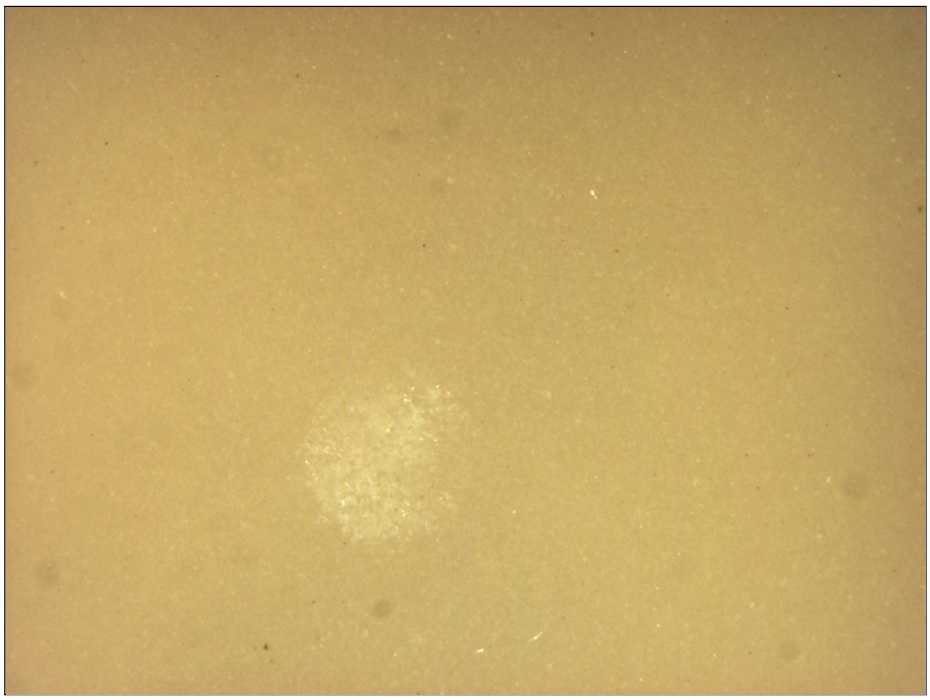

Fig. 6: **Ceramco®3** after wear test (sample No. 4). The contact area is indicated by the bright spot.

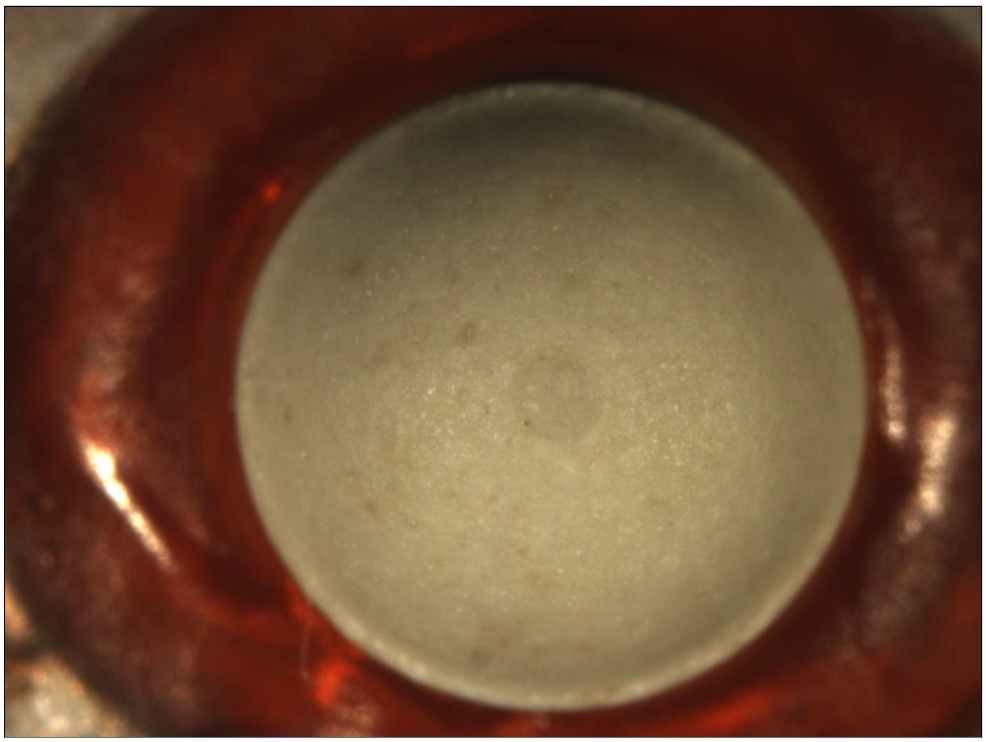

Fig. 7: Situation of the antagonist after the wear test in contact with **BruxZir** (sample No. 4).

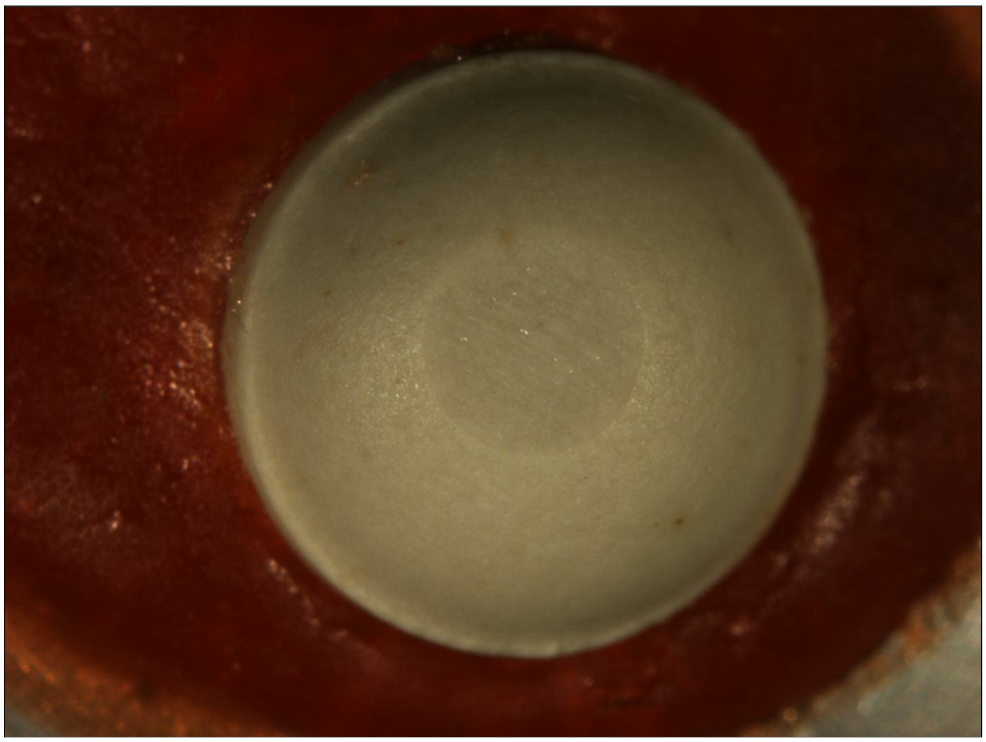

Fig. 8: Situation of the antagonist after the wear test in contact with **Ceramco®3** (sample No. 6).

Topography

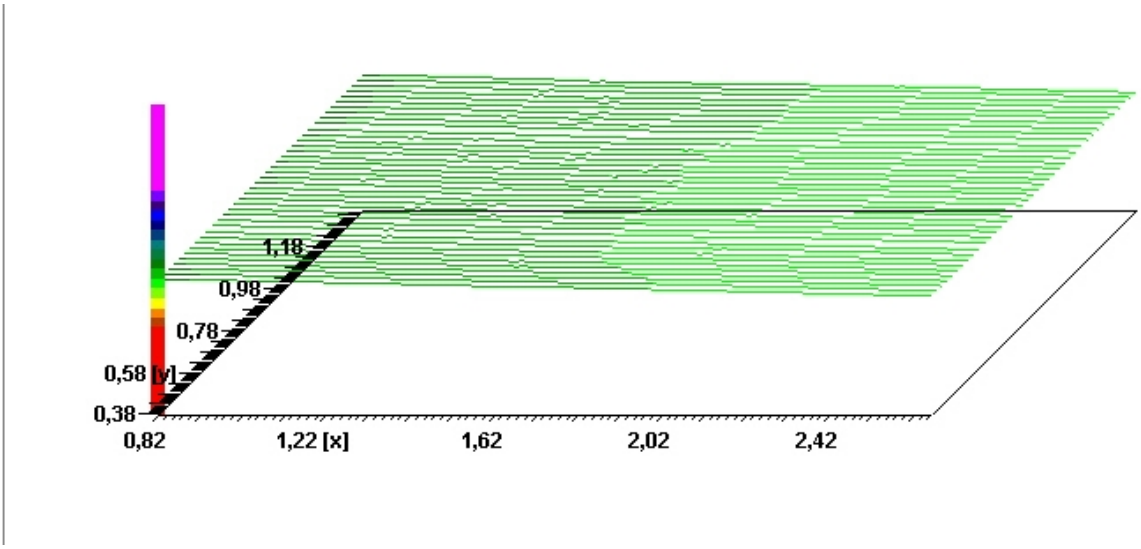

Fig. 9: Example of the topography of **BruxZir** after wear test (sample No. 4).

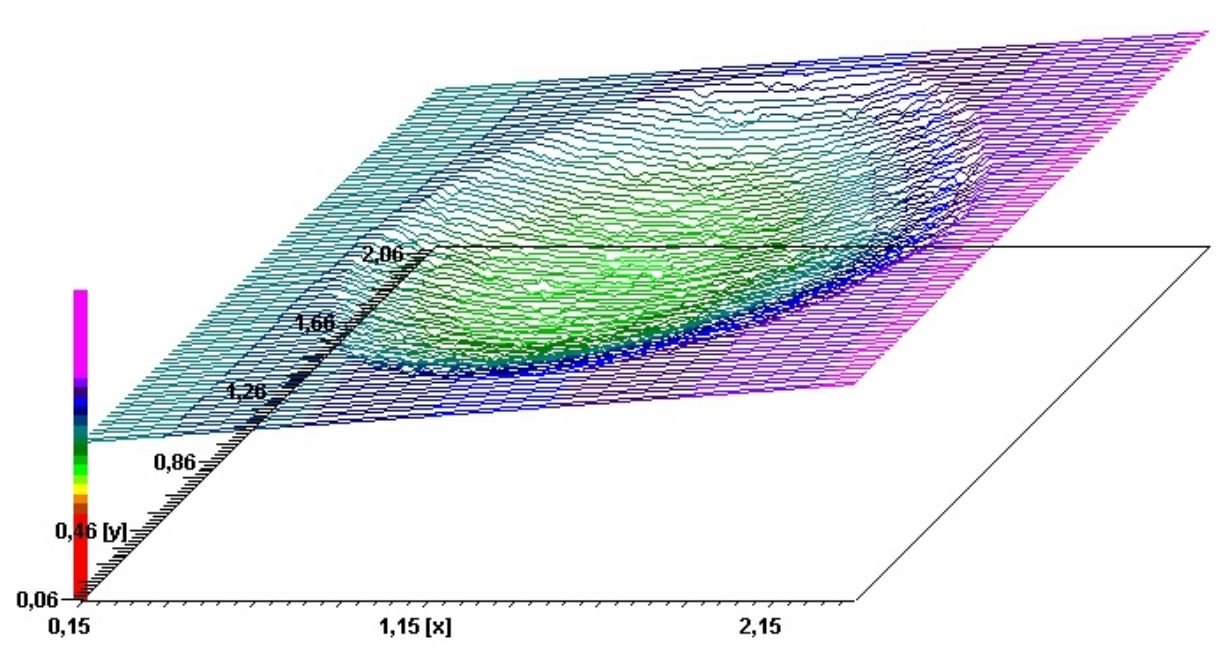

Fig. 10: Example of the topography of **Ceramco®3** after wear test (sample No. 2).

D-Profile

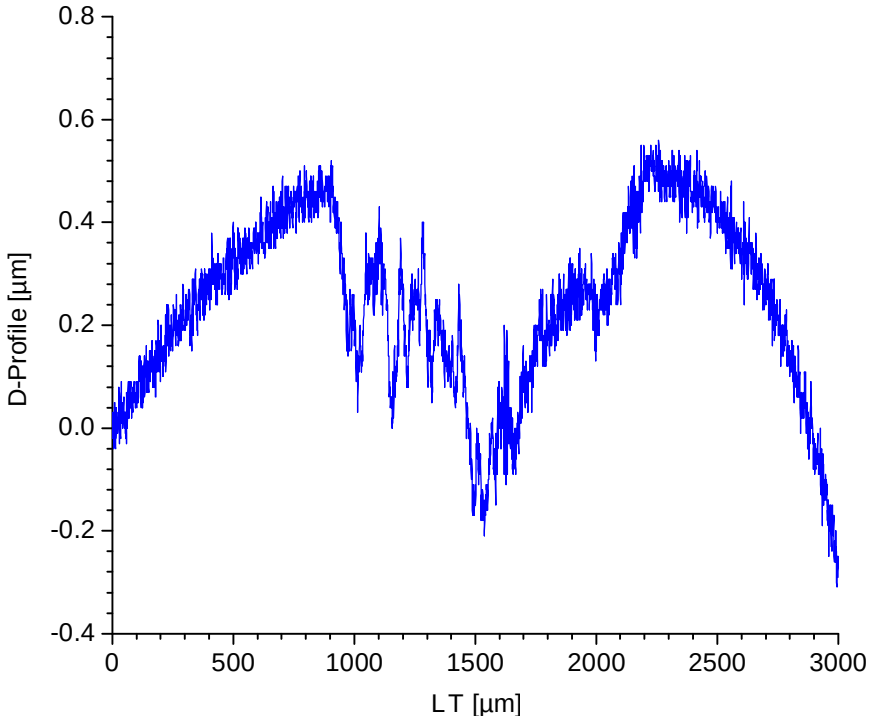

Fig. 11: Example of a single wear profile of **BruxZir** (sample No. 10, line 45).

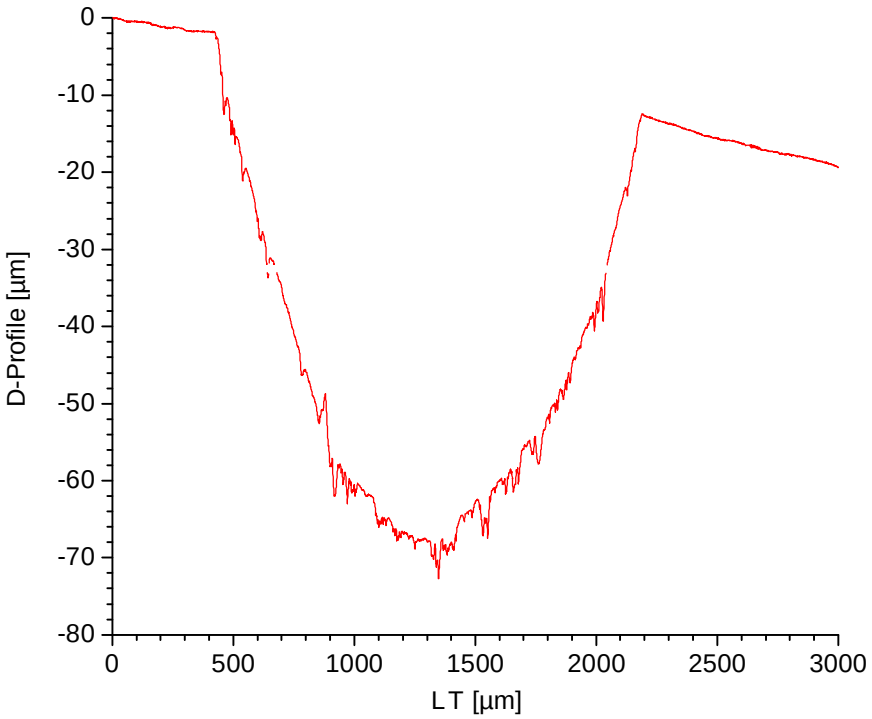

Fig. 12: Example of a single wear profile of **Ceramco®3** (sample No. 2, line 45).

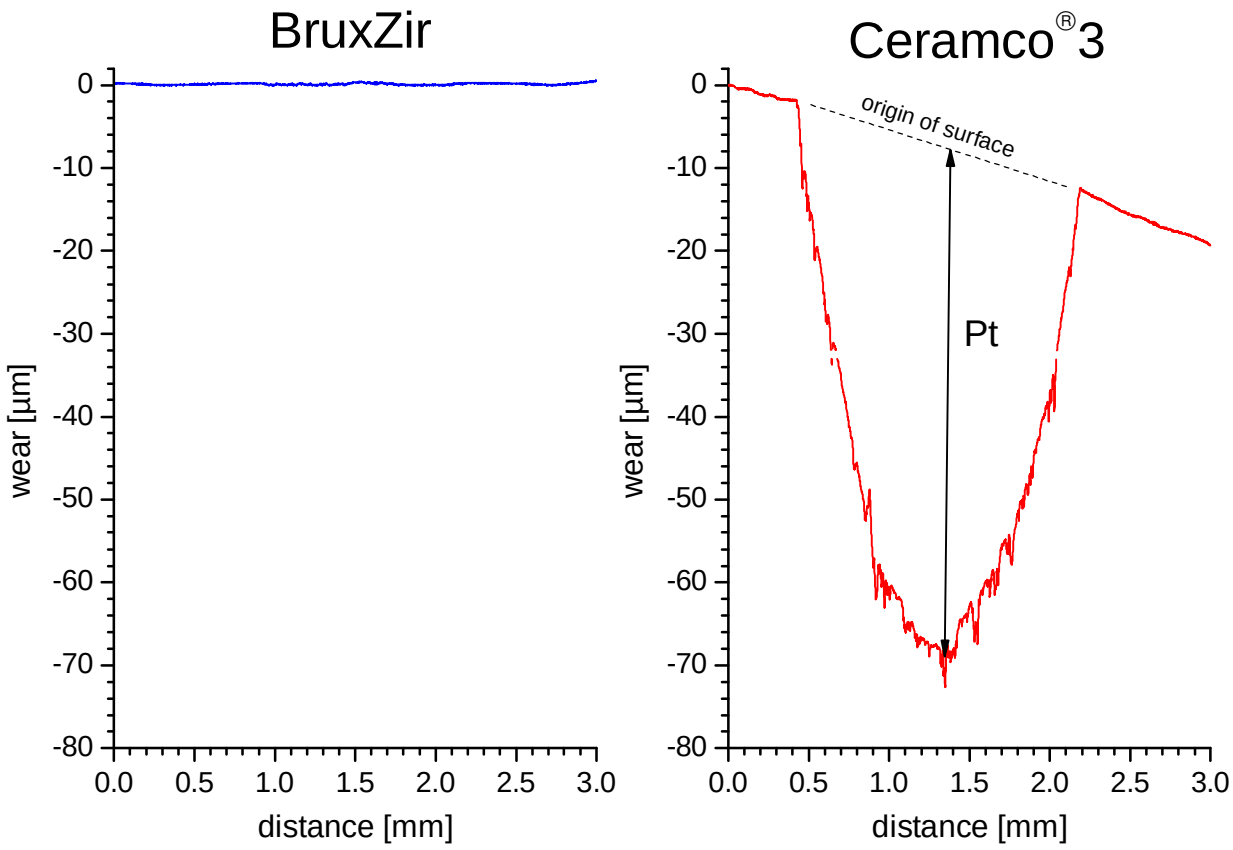

Fig. 13: Comparision of wear of BruxZir and Ceramco®3.

Statistics

The significance Pt values of BruxZir and Ceramco 3 and the values of antagonist height loss was evaluated using t-test ($p<0.05$). The wear differences between the materials as well as between the antagonists (Steatite balls) was significantly different.

Summary

- After 1.2 million wear cycles under a load of 5 kg, BruxZir revealed barely detectable wear with a measured mean value of 1 ± 1 µm.
- Compared to BruxZir, wear of Ceramco®3 with a mean value of 54 ± 22 µm was clearly higher.
- The wear of the antagonist situation (Steatite ball) was found to be significantly lower with BruxZir (72 ± 21 µm) than with Ceramco®3 (110 ± 48 µm).

Tübingen, 15 September 2010

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Contractor/Investigator